

# ESTABLISHMENT OF *UROPHORA QUADRIFASCIATA* (DIPTERA: TEPHRITIDAE) AND *CHRYSOLINA QUADRIGEMINA* (COLEOPTERA: CHRYSOMELIDAE) IN PORTIONS OF EASTERN UNITED STATES<sup>1</sup>

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**ABSTRACT:** This paper presents the first recorded distribution in the eastern United States of the introduced weed biocontrol agents *Urophora quadrifasciata* (Diptera: Tephritidae) and *Chrysolina quadrigemina* (Coleoptera: Chrysomelidae). The seed-head fly *U. quadrifasciata*, released in North America in the early 1970's for the control of spotted and diffuse knapweed (*Centaurea* spp.), is recorded from numerous localities in New York, Pennsylvania, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, and New Jersey. The leaf beetle *C. quadrigemina*, released in the mid-1940's for the control of St. Johnswort (*Hypericum perforatum*), is also documented from the northeastern U.S. with records from New York, Pennsylvania, Ohio, West Virginia, and Maryland. A brief review of the history and background information on the success of these two weed biocontrol agents in North America are presented. Each of the biocontrol agents are also briefly described.

This paper provides a brief review and background information on two classical weed biocontrol projects that continue to attain moderate success in managing two of North America's most dominant and abundant introduced weeds on uncultivated land: spotted knapweed (*Centaurea maculosa* Lamarck) and St. Johnswort (*Hypericum perforatum* L.). The principal focus of this paper emphasizes new distributional data in the eastern United States for the introduced fruit fly *Urophora quadrifasciata* (Meigen) and the leaf beetle *Chrysolina quadrigemina* (Suffrian). Both biocontrol agents were primarily released in western North America for control of spotted knapweed and St. Johnswort, respectively. These distributional records provide the first evidence of establishment of these introduced biocontrol agents in the eastern United States.

## I. The weed: *Centaurea maculosa* (Asteraceae)

Spotted knapweed is a herbaceous composite and short-lived perennial introduced from Europe to the dry rangelands of western North America (Harris, 1980; Harris & Myers, 1984). Because of its allelopathic

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properties, low forage value, and drought adaptations, this knapweed species has been able to displace and outcompete most other herbaceous plants over vast areas of its new homeland (Harris & Myers, 1984). It was first collected in North America at Victoria, British Columbia in 1893 (Groh, 1943). In western Canada, it is distributed in British Columbia and Alberta (Watson & Renney, 1974). The main areas of infestation (> one million ha) are confined to the western United States in Montana, Idaho, Washington, and Oregon (Maddox, 1982). In eastern North America, this weed is common in Ontario, Quebec, and the Maritimes in Canada (Frankton & Mulligan, 1970), and along roadsides and in fields and waste areas in the northeastern and northcentral United States (Cox, 1985).

### The biocontrol agent: *Urophora quadrifasciata*<sup>1</sup> (Tephritidae)

Members of *Urophora* Robineau-Desvoidy (Diptera: Tephritidae) have been widely employed as biocontrol agents of thistles and knapweeds of the composite family Asteraceae (=Compositae). The genus contains almost 100 known species distributed in Europe, temperate Asia, Africa and the New World (White & Elson-Harris, 1992). Two *Urophora* species, both of European origin and collectively referred to as the seed-head flies, have been successfully introduced into western North America for biocontrol of spotted knapweed (*C. maculosa*) and diffuse knapweed (*C. diffusa* Lamarck). *Urophora affinis* (Frauenfeld) and *U. quadrifasciata* (Meigen) oviposit into the developing inflorescences of *Centaurea* species, induce gall formation, and ultimately reduce seed production (Harris, 1980; Harris & Myers, 1984).

The usually univoltine *U. affinis* was originally released in British Columbia (Ned's Creek) in 1970 and 5 western states in 1973 (Harris, 1980; Maddox, 1979; Story & Anderson, 1978; Story, 1985). By 1992, *U. affinis* had been confirmed as established and increasing in abundance in British Columbia, Idaho, Oregon, Montana, Washington and Wyoming (Julien, 1992). Releases of *U. affinis* occurred in the east in 1971 (Ontario), 1979-1980 (Quebec), and 1983 (Maryland and New York) (Harris & Myers, 1984; pers. commun., Stephen D. Hight, USDA-ARS, Insect Biocontrol Laboratory, Beltsville, MD). Eastern establishment had been confirmed as of 1992 in New York, Quebec, and Virginia (Julien, 1992).

<sup>1</sup> In the Palearctic, *Urophora quadrifasciata* may actually represent a species complex (see White & Clement, 1987), with more than one species confused under the name *quadrifasciata*.

The bivoltine *U. quadrifasciata* was first introduced in 1970 at Ned's Creek, British Columbia, but was not released in the western United States (Story, 1985). By May 1981, larvae of *U. quadrifasciata* had been found in spotted knapweed seed heads examined at a site in extreme northwest Montana, ca. 400 km from the Ned's Creek original release site (Story, 1985). By 1982, *U. quadrifasciata* was known to be established in northwest and westcentral Montana (Story, 1985). Specimens of *U. quadrifasciata* had been released and become established in Quebec in 1979 (Julien, 1982) and 1980 (Harris & Myers, 1984). Between 25-31 May 1983, seed heads of field-collected spotted knapweed from British Columbia were released by USDA-ARS personnel at 3 sites in New York (Warren, Essex, and Tompkins counties) and at Beltsville, Maryland. This material contained larval stages of both *U. quadrifasciata* and *U. affinis*. A 1985 follow-up survey recovered only *U. affinis* at the Warren and Essex County release sites located in the Adirondack region of northern New York (pers. commun., S. D. Hight).

In Tompkins Co. (Trumansburg), New York, during July 1990, numerous small tephritid flies were collected from the immature flower heads of tyrol knapweed, *C. dubia* Suter, a common knapweed of the fields and roadsides of southeastern Canada and northeastern U.S. (Gleason & Cronquist, 1991). The flies were identified as *U. quadrifasciata* (by the author and later confirmed), and a survey was initiated to determine the geographic range in the northeast of this introduced seed-head fly. The survey was conducted throughout portions of the northeastern states during June-September 1990-1992. During the survey, no specimens of *U. affinis* were collected from knapweed.

In the following list of distributional data for *U. quadrifasciata*, the abbreviations ERH (for the author) and AGW (for A. G. Wheeler, Jr.) for collectors are used; dates of collection are expressed as "day-month (Roman numeral)-year"; and hosts are abbreviated as follows: *C. maculosa*, spotted knapweed (SK); *C. dubia* (= *C. nigrescens* & *C. vochinensis*), short-fringed knapweed (SFK); and *C. jacea*, brown knapweed (BK). Treatment and usage of scientific and common names of *Centaurea* follow Gleason and Cronquist (1991). The data below are also mapped in Figure 1. All specimens, unless stated otherwise, are deposited in the Cornell University Insect Collection. The author and A. G. Wheeler, Jr. take responsibility for the host plant identifications, with the exception of *C. dubia* (see acknowledgments).

UNITED STATES: CONNECTICUT: Tolland Co., 1-84 West, N. of E. Willington, 11-VIII-90, AGW, SK. MASSACHUSETTS: Plymouth Co., Rte. 58, nr. South Carver, 5-VIII-90, AGW, SK. Worcester Co., Gardner, 4-VIII-90, AGW, SK. NEW HAMPSHIRE: Hillsboro Co., Nashua, 5-VIII-90, AGW, SK. NEW JERSEY: Hunterdon Co., Exit 11 on

Rte. 78, 12 mi. E. Phillipsburg, 10-VIII-91, ERH, SK. Sussex Co., High Point St.Pk., 28-VII-90, AGW, SK; Rte. 23, nr. High Point St. Pk., 28-VII-90, AGW, SK. NEW YORK: Allegany Co.: Rte. 17, Exit 33 (to Alfred), 7-VIII-92, ERH, SK; Rte. 17, 0.5 mi. E. Exit 37, 7-VIII-92, ERH, SK; Alfred, 7-VIII-92, ERH, BK. Broome Co.: Binghamton, Junct. Rte. 81 and Rte. 12, 17-VIII-90, ERH, SK. Chemung Co., West Elmira, 30-VI-92, ERH, SK; Pine City, 30-VI-92, ERH, SK; Elmira Heights, 7-IX-92, ERH, SK. Chenango Co., Brisben, 17-VIII-90, ERH, SK; Norwich, 17-VIII-90, ERH, SK. Clinton Co., Rte. 456 @ junct. Rte. 87 E. of Beekmantown, 29-VIII-92, AGW, SK; I-87, Exit 36, S. of Plattsburgh, 2-VIII-92, AGW, SK. Dutchess Co., I-84 West, rest area nr. Stormville, 11-VIII-90, AGW, BK. Greene Co., I-87 North, nr. Catskill, 3-VIII-90, AGW, SK. Jefferson Co., Plesis, 16-VIII-92, AGW, SK; Wellesley Island St.Pk., 16-VIII-92, AGW, SK. Madison Co., DeRuyter, 17-VIII-90, ERH, BK?; New Woodstock, 14-VII-91, ERH, SK. Ontario Co., nr. E. Victor (Farmington), 5-VII-92, ERH, SK. Orange Co., I-84 East, nr. Middletown, 3-VIII-90, AGW, SK. Putnam Co., Rte. 202, nr. Brewster, 11-VIII-90, AGW, BK. Rensselaer Co., Johnsonville, 3-VIII-90,



Figure 1. Northeastern United States. Distribution of *Urophora quadrifasciata* based on examined specimens (dots). Known release sites (NY: Essex, Tompkins, and Warren counties; MD: Beltsville) (stars).

AGW, SK. Saratoga Co., I-87 North, nr. Ushers, 3-VIII-90, AGW, SK. Schuylker Co., Alpine Junction, 6-VIII-92, ERH, SK; Watkins Glen, 31-VIII-90, 15-VIII-92, ERH, SK. Steuben Co., Bath, 31-VIII-90, ERH, SK. Tioga Co., Owego, 17-VIII-90, ERH, SK; Waverly, 17-VIII-90, ERH, SK. Tompkins Co., Ithaca, 14-VI-91, ERH, SK; Trumansburg, 21-VII-91, 27-VI-92, ERH, SK; Town of Ulysses, N. of Jacksonville, 15-VIII-89, 11.13.16-VII-90, 15-VIII-90, 12.15.17.20.27-VI-91, 25-VII-91, 15-VIII-91, 22-VI-92, 10.12.29-VII-92, ERH, SK. Ulster Co., Mohonk Preserve, nr. New Paltz, 3-VIII-90, AGW, SK. Warren Co., Peggy Ann Rd., W. of Glens Falls, 3-VIII-90, AGW, SK. Yates Co., 10 mi. N. of Watkins Glen, @ junct. Rte. 42 and 14, 4-IX-90, ERH, SK. PENNSYLVANIA: Bradford Co., Sayre, 17-VIII-90, ERH, SK; Wysox, 17-VIII-90, ERH, SK. Carbon Co., Rte. 534, 0.3 mi. S. of junct. Rte. 940 nr. East Side, 15-VII-90, AGW, SK. Cumberland Co., Rte. 114 @ junct. I-81, nr. Hogestown, 18-VII-90, AGW, SK. Dauphin Co., Rte. 39, nr. junct. Rte. 322 N. of Harrisburg, 16-VII-90, AGW, SK. Lackawanna Co., I-84 East, Mt. Cobb exit, 25-VII-90, AGW, SK. Lancaster Co., Rte. 272, N. of Buck, 24-VII-090, AGW, SK. Lebanon Co., Rte. 934, Indiantown Natl. Cem., 15-VII-90, AGW, SK. Luzerne Co., Rte. 93 @ I-81, nr. West Hazleton, 15-VII-90, AGW, SK. Lycoming Co., nr. Loyalsock, 28-VII-91, ERH, SK; Muncy, 20-VII-90, K. Valley, SK. Monroe Co., Tobyhanna, 21-VII-90, AGW, SK. Pike Co., Rte. 402, nr. Blooming Grove, 28-VII-90, AGW, SK. Schuylkill Co., Rte. 443, nr. New Ringgold, 23-VII-90, T. Price, SK; Frackville, 15-VII-90, AGW, SK. Sullivan Co., Sonestown, 20-VII-90, K. Valley, SK. Susquehanna Co., Montrose, 17-VIII-90, ERH, SK. Wayne Co., Angels, 21-VII-90, AGW, SK. RHODE ISLAND: Kent Co., West Warwick, 5-VIII-90, AGW, SK. VERMONT: Chittenden Co., Camp Johnson, Colchester, 28-VIII-92, AGW, SK. Franklin Co., Missisquoi Natl. Wildlife Refuge, 28-VIII-92, AGW, SK.

**Comments.** Adults of *U. quadrifasciata* and *U. affinis* are superficially similar. Females of both species can be easily separated using the key in White & Clement (1987:575). Among the chief characters that distinguish *U. quadrifasciata* are the four complete, transverse, black bands and yellow base of the wing, with the first (or basal) and second transverse bands broadly united at the costal margin (see Figure 8 of Plate II in Freidberg & Kugler, 1989). In contrast, adults of *U. affinis* are recognized by having 3 or 4 transverse bands (variable in intensity and completeness), with the first band, when present, less pronounced than the other three and separated from the second transverse band (as in Figures 2-3 of Plate II in Freidberg & Kugler, 1989).

The Animal and Plant Health Inspection Service, Plant Protection and Quarantine (APHIS-PPQ) of the USDA is initiating a biocontrol program for diffuse and spotted knapweed in the eastern states (states invited to participate in 1992 include Pennsylvania, New York, Michigan, and Virginia). The locality records reported herein represent a "prerelease inventory", establishing important base line data on existing *U. quadrifasciata* populations in eight northeastern states.

## II. The weed: *Hypericum perforatum* (Hypericaceae)

St. Johnswort (also klamath weed or goatweed), *Hypericum perforatum*, a weed native to Europe, northern Africa, and large portions of

Asia to China and Japan, was introduced into Australia and North America. On the latter continent, it has become a serious weed on rangelands in dry areas (Johansson, 1962). The first known introduction of St. Johnswort into the United States was reported in 1793 near Lancaster, Pennsylvania. By 1900 it had spread westward and was reported in California around the Klamath River, which provides the basis for one of the plant's common names (Rosenthal *et al.*, 1984). It is a hardy, deep-rooted, perennial herb occurring in neglected meadows, fields, and pastures and along roadsides from Newfoundland to Manitoba, south to Florida and Texas, and in the far West from British Columbia to central California (Cox, 1985). It remains a noxious rangeland weed only in the western United States (Johansson, 1962).

In heavily infested areas, this weed is especially injurious by displacing valuable and desirable forage plants. It is also toxic to livestock when ingested in considerable quantities, causing a photodermatitis on unpigmented areas of grazing livestock exposed to direct sunlight (Johansson, 1962).

#### The biocontrol agent: *Chrysolina quadrigemina* (Chrysomelidae)

The first use of insects as a means of weed control in North America was initially attempted in the mid-1940's with two European species of leaf beetle (*Chrysolina*) that feed on St. Johnswort, *H. perforatum* (Holloway & Huffaker, 1951). *Chrysolina hyperici* (Förster) and *C. quadrigemina* (Suffrian) [= *gemellata* auct. and *geminata* auct.] have become established in release areas in western and eastern North America, with the latter species exhibiting a greater ability to increase its distributional range, particularly in California (Holloway & Huffaker, 1951).

*Chrysolina hyperici* was introduced into California (via Australia) in 1945 and is now established in many localities in the West, including Oregon, Washington, Idaho, Montana, Colorado, and British Columbia. Similarly, *C. quadrigemina* was introduced into California (via Australia) in 1946, and is also established in the same areas as *C. hyperici*. Another species, *C. varians* (Schaller), was introduced for the biocontrol of *Hypericum* in British Columbia where it remains established and apparently restricted (Johansson, 1962; Brown, 1962).

Populations of *H. perforatum* were dramatically reduced when both *C. hyperici* and *C. quadrigemina* were introduced into Australia (Clark, 1953), the United States (Holloway & Huffaker, 1951; Holloway, 1957), and western (British Columbia) and eastern Canada (Ontario and Nova Scotia) (Smith, 1958; Harris & Maw, 1984). A relatively small number of specimens of *C. hyperici* (252) and *C. quadrigemina* (182) were originally released in eastern Ontario in 1969 and 1970, respectively, for control of

St. Johnswort (Harris & Maw, 1984). Fields *et al.* (1988) demonstrated that 18 years after their initial release both species of leaf beetle had spread nearly 90 km from the original release site near Picton, Ontario. They also concluded that the present distribution of *Chrysolina* spp. in eastern Canada was probably due to natural dispersal, and that both species were capable of finding widely separated stands of the host plant.

No systematic release of either *Chrysolina* species has occurred in the eastern United States. However, *C. quadrigemina* has been collected from several widespread localities in New York, Pennsylvania, Maryland, West Virginia, and Ohio, since 1989. Several states in the east have not been surveyed; therefore, no statement can be made about the presence or absence of this species in these regions. The known distributional records for *C. quadrigemina* document its establishment and range expansion in the eastern United States, apparently resulting from a natural dispersal of populations from eastern Ontario. These data are recorded below and mapped in Figure 2. All specimens were collected from *H. perforatum*, unless stated otherwise. The host plant iden-

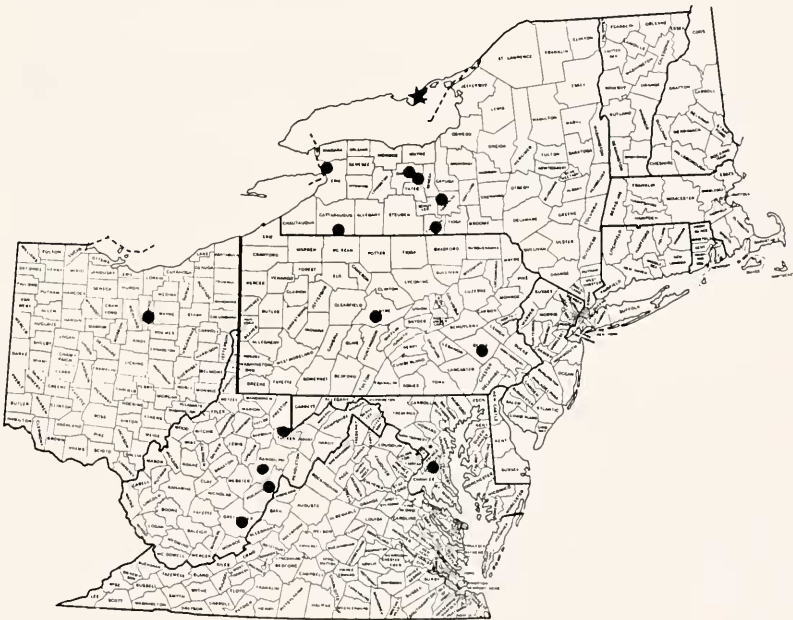


Figure 2. Northeastern United States. Distribution of *Chrysolina quadrigemina* based on examined specimens (dots). Known release site (near Picton, Ontario) (star).

tifications, where noted, are provided by the author and other collectors. The leaf beetle determination is the responsibility of the author.

The New York and Pennsylvania specimens are deposited in the Cornell University Insect Collection; Ohio and West Virginia specimens in the collection of the West Virginia Department of Agriculture, Charleston, WV; and Maryland specimens in the collection of the Maryland Department of Agriculture, Annapolis, MD.

UNITED STATES: MARYLAND: Prince Georges Co., Brandywine, 1-V-91, C. L. Staines. NEW YORK: Cattaraugus Co., Allegany St. Pk., 24 July 1985, A. E. Hajek. Chemung Co., no specific locality, 1-VII-90, C. Klass. Erie Co., Tonawanda, 3-VII-92, E. R. Hoebeke. Ontario Co., Geneva, 16-VI-91, ERH; along Rte. 90, W. of Geneva exit, 16-VI-91, ERH. Tompkins Co., Ithaca, 10-VII-89, 12-IX-90, C. Klass; Ithaca, Sept.-Oct. 1990, R. Campbell (student collection); Ithaca, Forest Home Wildflower Garden, 1-X-89, ERH; Town of Ulysses, N. of Jacksonville, 15.17.20-VI-91, ERH; Trumansburg, fairgrounds, 1-VII-90, ERH; Trumansburg, Falls Rd. nr. H. A. Smith Woods, 6-VII-89, ERH; Trumansburg, Taughannock Falls St. Pk., 6-VII-89, ERH. OHIO: Ashland Co., Mohican Mem. St. For., 30-V-87, S. M. Clark. PENNSYLVANIA: Berks Co., Slote Nurseries, nr. Angelica, 25-X-90, AGW. Centre Co., Scotia Barrens, 29-VI-91, A. G. Wheeler, Jr. WEST VIRGINIA: Greenbrier Co., Anthony, 9-VI-92, SMC. Pocahontas Co., Cass, 8-VII-92, SMC, ex. *H. punctatum*. Randolph Co., Cheat Mountain, 1 mi. n. Barton Knob, 3800 ft. elev., 8-VII-92, SMC. Tucker Co., Dolly Sods Scenic Area, 16-IX-92, SMC.

**Comments.** Of the sixteen *Chrysolina* species recorded in North America (Brown, 1962), *C. quadrigemina* can be generally distinguished from its congeners in eastern North America by the following characteristics: its color (blue, blue-green, brassy green, or bronze individuals with venter and legs dark blue or blue-green); its distinctly larger, more robust size (6.0-7.1 mm); and, in the male, by the presence of a saucer-shaped impression on abdominal sternite V, and by the size and details of the aedeagus (Brown, 1962; Wilcox, 1972; Frazer & Emberson, 1987).

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